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AMERICAN ASSOCIATION OF WINE ECONOMISTS

AAWE WORKING PAPER
No. 220
Economics

THE IMPACT OF CLIMATE CHANGE ON FIRM ADAPTATION: A STUDY OF WINE FIRMS IN SOUTH AUSTRALIA

Jeremy Galbreath

Nov 2017

www.wine-economics.org

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Jeremy Galbreath
School of Management/Curtin Graduate School of Business
Curtin University
78 Murray Street, Perth 6000 Western Australia
jeremy.galbreath@gsb.curtin.edu.au
+61 8 9266 3568 (phone)

Abstract: This study explores a relatively little understood aspect of climate change: to what extent *physical* changes in the climate impact on firm behavior. To explore the impact of physical changes in climate, changes in both temperature and rainfall are studied with respect to adaptive behavior. For a sample of 207 wine firms operating in South Australia, this study finds that changes in temperature and rainfall are associated with adaptive practices. Further, because of the nature of acquiring and leveraging information and knowledge on climate change to affect adaptation, the study predicts that absorptive capacity will moderate the relationship between climatic changes and adaptive practices. This postulate finds support. The study advances research on climate change and firm behavior. Contributions of the findings are discussed along with limitations and future research opportunities.

Introduction

Responding to climate change can be thought of as a moral imperative (Carrell, 2012; Galbreath, 2014). In fact, according to Driscoll and Starik (2004) and Starik (1995), given firms' dependence on natural resources to produce goods and services, there is a moral obligation to treat the natural environment as a stakeholder. This follows an environmental ethic of the stewardship of resources and an obligation to respect non-human nature's bounty and limits. If climate change, then, "is one of the greatest challenges we confront in the 21st century" (Howard-Grenville et al. 2014, p. 615), and if there is belief that there is a moral obligation to respond, what actually drives firms to adapt to changes in the climate?

Research largely suggests five key factors. First, some firms do feel a sense of stewardship and moral commitment to treat the environmental well and hence adapt to look after natural resources (Galbreath 2014). Second, when firms become aware of issues surrounding climate change, some respond by adapting (Arnell and Delaney 2006). Awareness may come through belief in climate science, professional reports, media coverage, or other informational sources (Fleming et al. 2015; Hoffmann et al. 2009; Pinske and Gasbarro 2016). Third, other research suggests that adaption to climate change occurs when firms perceive that they are vulnerable to climate-related disruptions, such as droughts (Bremer and Linnenluecke 2016; Linnenluecke et al. 2015). Fourth, other firms adapt based on their framing of the issue, or the patterned (conscious and unconscious) ways in which they think about and act on climate change (Dewulf 2013). Lastly, institutional advocacy and policy places pressure on firms to respond to climate change (Jeswani et al. 2008). One assumption of all of these perspectives is that climate change is occurring.

More specifically, while climatic conditions have varied throughout the history of the world (Pierrehumbert 2010), recent scientific evidence suggests that since the mid-1970s, the global land surface temperature has warmed at a rate about twice the ocean surface temperature and, measured over the last 50 years, the world has warmed at nearly twice the rate of that of the past 100 years (Intergovernmental Panel on Climate Change [IPCC] 2007). Further, scientific evidence demonstrates that global rainfall is changing from long-term averages, with increases or decreases depending on regional location (IPCC 2007). Scientific findings such as these demonstrate physical manifestations of changes in the natural environment, which can alter the Earth's ecosystem services (e.g., fibers, water, soil, photosynthesis, temperature, timber) (Winn and Pogutz 2013), ultimately impacting on consumer, production, and even regulatory strategies (Galbreath 2014). Yet, there is little understanding of if, or why, *actual changes* in climate drive adaptive responses on the part of firms. In other words, there has been little empirical investigation in the management literature as to whether or not nature *directly* impacts on firms' adaptive capacity (Bergmann et al. 2016; Tashman and Rivera 2016). Lack of empirical investigation is surprising, particularly given that the very premise of climate change is that climatic conditions are changing, and that these physical changes are purported to impact on firms (Linnenluecke et al. 2012; Winn et al. 2011).

Motivated by this research gap, this paper makes a few key contributions. First, to understand why climatic changes would be expected to stimulate adaptive action on the part of firms, a relatively new theoretical framework is employed: natural stakeholder-based theory (NSBT) (Driscoll and Starik 2004; Haigh and Griffiths 2009; Starik 1995). NSBT predicts that direct, physical changes in the natural environment (e.g., changes in temperature or rainfall) should influence adaptive practices, yet, as noted by Bergmann et al. (2016) and Tashman and Rivera (2016), remains a proposition that has seen little empirical investigation. This paper contributes to the literature by empirically testing NBST and by capturing changes in temperature and rainfall for a 30-year period. Second, while physical changes in climate may stimulate adaptive response, there may be contingencies that affect the strength (or weakness) of any such relationship (Tashman and Rivera 2016). Because this study examines the rate at which firms adapt to external conditions and stimuli, absorptive capacity is considered as a moderating variable. Absorptive capacity is critical to a firm's ability to absorb information and stimuli from the external environment, combine with existing knowledge, and apply it to adaptive and technical change (Cohen and Levinthal 1990). Hence, the stronger a firm's absorptive capacity, the stronger the expected relationship between climatic changes and adaptive practices. Yet, within the context of physical, climatic changes and absorptive practices, there has been little empirical investigation (Bergmann et al. 2016; Tashman and Rivera 2016). Lastly, there is some skepticism among managers that climatic changes are occurring and that firms need to respond in an adaptive way (Galbreath 2014). This study provides evidence as to real changes in climate, and to what extent these changes guide firm behavior in terms of adaption, and what such adaption consists of.

Theoretical framework

Natural stakeholder-based theory (NSBT)

Following Mitchell et al. (1997), Driscoll and Starik (2004), and Starik (1995), Haigh and Griffiths (2009) build NSBT and posit that the natural environment is a primary stakeholder *because of* climate change. Their argument rests on two key premises. First, firms *depend* on the natural environment. Virtually all business activity depends on the resource and economic inputs the natural environment provides (Dyllick and Hockerts 2002). If the resources and inputs nature provides are disrupted, run out, or are otherwise put at risk through climate change, economic activity could be constrained (Stern 2007). Similarly, Haigh and Griffiths (2009) suggest that, following Freeman (1984), the natural environment can affect, or can be affected by, business activity. For example, industrial disasters have negatively affected the natural environment (Stead and Stead 2000). On the other hand, scholars argue that climate change has "the potential to significantly affect business" (Kolk and Pinske 2007, p. 371).

The second key premise that Haigh and Griffiths (2009) put forth is that climate change has salience as a stakeholder. Salience is posited by Mitchell et al. (1997) as a means to determine which stakeholders managers should give due attention. Hence, to be a salient stakeholder, climate change must have *power*, *legitimacy*, and *urgency* (Haigh and Griffiths 2009). Power can be construed in two ways. First, power can be defined as an exertion of the will of social actors (Finkelstein 1992). In the case of climate change, an "exertion of the will" of institutions requires firm attention. For example, regulatory mandates have given climate change "power" in that GHG reductions have been instituted by governments in some parts of the world, such as the UK-ETS and EU-ETS schemes. Second, power can be defined by physical force (Driscoll and Starik 2004; Starik 1995). In general, climate change is argued to have physical power because some weather changes, for example, can "destroy resources, make them unavailable or change their state without warning or negotiation" (Haigh and Griffiths 2009, p. 354). The logic being this type of disruption to resources can constrain businesses from fulfilling their objectives (Freeman 1984; Mitchell et al. 1997); therefore, according to Haigh and Griffiths (2009), climate change meets the criteria of a primary stakeholder in that climate change can be "powerful" enough to affect business operations (Freeman 1984).

Legitimacy is defined by the values of those with social power (Stinchcombe 1968). In the case of climate change, Driscoll and Starik (2004) argue that the scientific academy has social power in that they have reached a consensus that the planet is warming, and that human activity is the likely cause. In fact, in May 2013, the daily mean concentration of carbon dioxide in the atmosphere exceeded 400 parts per million for the first time in recorded history—a claimed demonstration of human activities' impact on climate change (Carrington 2013). Climate change is therefore rooted in scientific discovery and although there are detractors and skeptics, the major scientific bodies generally support the scenario of a human-induced warming of the planet (Australian Academy of Science 2010; IPCC 2007; National Academy of Sciences 2008; The Royal Society 2010). Hence, climate change is argued to have legitimacy. Urgency is the extent that a stakeholder requires immediate attention. In the case of climate change, climatic events (e.g., prolonged or more frequent droughts, heat waves, rising temperatures) associated with climate change are already affecting business operations (Davenport 2014; Fenner 2009; Wahlquist 2009), and are predicted to increase in the future (Hätel and Pearman 2010; Slawinski et al. 2017). Hence, Haigh and Griffiths (2009) argue that climate change requires urgent attention.

Hypotheses

Temperature

According to scientific inquiry, the earth is warming, specifically as relative to temperatures 100 years ago (IPCC 2007). Increases in temperature can effect firms. For example, ski resorts may encounter less snowfall because of warming winters. Agriculturists may be susceptible to crop failure or may risk poorer harvests as increasing temperatures could scorch fields. Alternatively, energy companies may confront power outages as hotter summer temperatures, or extreme heat days, drive demand beyond capacity. In another example, global drinks giant Coca-Cola claims that as a result of climate change, increased droughts have been economically disruptive to its operations and that "When we look at our most essential ingredients, we see [climate change events] as threats" (Davenport 2014, p. A1). Hence, following Haigh and Griffiths (2009), climate change can be argued to have legitimacy, as the scientific academy demonstrates documented increases in temperature since records began. Further, actual changes in the temperature, brought about by climate change, have power because they can and are impacting business operations (Davenport 2014; Fenner 2009; Galbreath 2011; Tashman and Rivera 2016; Wahlquist 2009), as well as impacting ecosystem services (Galbreath 2011, 2014; Winn and Pogutz 2013).

Changes in temperature, brought about by climate change, may also have urgency. There are two ways to consider urgency. First, some firms are already experiencing the effects of shifting climates, for example in the form of increased temperatures or more extreme heat days (Galbreath 2011; Webb et al. 20007, 2012). Such climatic shifts are impacting on the ability of firms to produce products. For example, in the wine industry, firms are reporting loss of grapes due to shifts in temperature (Fenner 2009; Wahlquist 2009). Alternatively, snowfall uncertainty due to a changing climate is being reported by ski resorts (Hoffmann et al. 2009; Tashman and Rivera 2016). Second, forecasted climate scenarios suggest an increase in global temperatures (IPCC 2007). Globally, temperatures are expected to rise from a minimum of 0.6° C to as much as 4.0° C by the end of the century (IPCC 2007). Further, extreme heat events are projected to become more frequent (IPCC 2007; Linnenluecke and Griffiths 2010; Linnenluecke et al. 2011; Linnenluecke et al. 2012; Winn et al. 2011). Such changes are expected to impact on ecosystem services, food production, industry, and human health—generally in a negative way (Winn et al. 2011). Hence, Haigh and Griffiths (2009) argue that temperature shifts induced by climate change have urgency in that, unless firms take adaptive action, they put themselves at risk (cf. Fleming et al. 2015; Hoffmann et al. 2009; Tashman and Rivera 2016; Slawinski and Bansal 2012).

The nature of climate change is such that temperatures are shifting from long-term averages. Based on the arguments of NSBT (Haigh and Griffiths 2009), temperature changes are therefore expected to have legitimacy, power, and urgency. In this sense, climate change is considered a primary stakeholders and primary stakeholders are ones where managers have a

"…clear and immediate mandate to attend to and give priority to that [stakeholder]" (Mitchell et al. 1997, p. 878). Thus:

Hypothesis 1. Climate change, as physically manifested in a change in temperature, is associated with adaptive practices.

Rainfall

Water is essential to sustain life. To meet the demands of a life-sustaining planet, the majority of the world relies on water supply from rivers, either directly or from reservoirs. The supply of water provided by rivers is sensitive to long-term changes in rainfall. According to the scientific evidence (IPCC 2007), changes to rainfall patterns in the last 100 years have varied. For example, increases in rainfall have been documented in North and South America, northern Europe, and northern and central Asia (IPCC 2007). Alternatively, in the Mediterranean, southern Africa, and parts of southern Asia, the documented scientific evidence demonstrates less rainfall (IPCC 2007). Further, over the last 50 years, the scientific evidence suggests that the frequency of heavy rainfall events have increased over most areas (IPCC 2007). Therefore, according to Haigh and Griffiths (2009), the fact that the scientific academy has studied and documented shifts in rainfall suggests that climate change has legitimacy.

Changes in rainfall are also expected to have power. Less rainfall and changes in runoff that affect water availability can be problematic. For example, Coca Cola Company uses significant amounts of water to produce their line of products. In fact, in 2015, Coca Cola used 300.19 billion litres of water to produce approximately 151.1 billion litres of product (Coca Cola 2016). Given that Coca Cola acknowledges the threat of climate change (e.g., less rainfall) to their key ingredients (e.g., water) (Davenport 2014), the company is on an aggressive campaign to improve water efficiency through continuous adaptive innovations (Coca Cola 2016). In another example, perennial crop producers depend on consistent rainfall. As rainfall decreases (or even increases) and extreme events, such as floods, increase, due to the impact of climate change, crop failure is occurring (Winn et al. 2011). Hence, shifts in rainfall due to climate change are argued to have power in that they can physically impact or effect business activity (Haigh and Griffiths 2009).

Variations in rainfall would also be expected to have urgency. In parts of the UK, water supply companies are projecting increases in demand by 2025 of up to 20 percent, yet, under climate change scenarios, may see a reduction in reliable water supplies by as much as 13 percent (Arnell and Delaney 2006). Alternatively, in California's Napa Valley, as much as 50 percent of current acreage used for wine production is projected to be lost, in part, due to a reduction of fresh water as a result of climate change (Renée and Thach 2014). Lastly, on a global scale, 100-year floods are projected to occur twice as frequently by 2050, while rainfall is likely to increase in higher-latitudes, and decrease in mid-latitude and subtropical regions, by as much as 30 percent by 2050 (Arnell and Gosling 2016; IPCC 2007). Rainfall changes are therefore expected to impact on agriculture production, water supply, energy production, and human health (IPCC 2007; Haigh and Griffiths 2009). Given the necessity of water, the effects on rainfall due to climate change are therefore argued to induce a sense of urgency (Haigh and Griffiths 2009; Slawinski and Bansal 2012).

Climate change is creating shifts in rainfall such that, according to NSBT, these shifts have legitimacy, power, and urgency. Therefore, as a primary stakeholder (Haigh and Griffiths 2009; Mitchell et al. 1997), firms would be expected to respond. Hence:

Hypothesis 2. Climate change, as physically manifested in a change in rainfall, is associated with adaptive practices.

Contingencies: Absorptive capacity

The scholarly treatment of adaptation and technical change acknowledges absorptive capacity as a critical factor (Cohen and Levinthal 1990). Absorptive capacity denotes learning systems which facilitates firms' adaptation to the external environment. Further, firms create organizational memories that are updated and leveraged as new knowledge is absorbed. Absorptive capacity is thus a firm's ability to identify, value, and apply knowledge for commercial ends (Cohen and Levinthal 1990). This capacity enables firms to add new knowledge to their existing knowledge base, to create new knowledge from a novel combination of new and existing knowledge, and to use this knowledge to adapt and change.

With respect to climate change and adaptation, NSBT posits that firms depend on the natural environment for eco-system services, while the natural environment has power, legitimacy, and urgency. If these postulates hold true, then firms would be expected to pay attention to changes in climate and acquire new knowledge about such climatic changes as they affect their businesses. However, not all firms may do this equally well nor learn equally well from any attention they give to the climate (Pinske and Gasbarro 2016). More specifically, if firms lack well-developed absorptive capacity, they are unlikely to maximize the value of new knowledge in ways that leads to greater implementations rates of adaptive practices (Pinske et al. 2010). This is because a high level of absorptive capacity is expected to ensure the adequate understanding and application of external knowledge (Cohen and Levithal 1990). Further, external knowledge about climate change could be tacit, complex, and new to the firm, and implies potential changes in business operations and processes (Haigh and Griffiths 2009). To take advantage of this knowledge, firms need to be able to recognize the value of the external knowledge while transforming their learning to design or alter operations, processes, and products to improve adaptation. In this sense, as firms confront climatic changes, their ability to maximize adaptive efforts may be limited if their absorptive capacity is weak. Alternatively, firms with structures and systems to source and process climate-relevant knowledge are expected to absorb such knowledge at a higher rate, leading to improvements in adaptation. Therefore:

Hypothesis 3. The relationship between climate change (change in temperature) and adaptive practices is moderated by absorptive capacity.

Hypothesis 4. The relationship between climate change (change in rainfall) and adaptive practices is moderated by absorptive capacity.

Methods

Sample and data collection

This study is part of an on-going research program on climate change conducted by the author. For this particular study, data were collected in three parts. First, data on adaptive practices was collected in 2012 via a primary survey of wine firms in Australia. The survey contained several sections on the study of various aspects of climate change as related to the wine industry. The wine industry is particularly well suited to study adaptive practices as the documented evidence suggests that firms are already experiencing the effects of a changing climate (Fenner 2009; Fleming et al. 2015; Galbreath 2011; Wahlquist 2009; Webb et al. 2007, 2012), as well as is predicted to face further disruption in the future (Hannah et al. 2013). To keep the project manageable and given a limited research budget, wine firms operating in South Australia comprised the sample. South Australia is Australia's largest producer of wine, and leads the country in wine exports, making firms here suitable for study. There were 680 wine firms operating in South Australia at the time of the survey, and 207 useable responses returned, equating to a 30 percent response rate. The CEO (or equivalent) was the targeted respondent for the survey.

Second, data on temperature and rainfall were collected over the 2013–2015 period. Temperature and rainfall data were collected from the Australian Bureau of Meteorology website (www.bom.gov.au). Third, to collect information on some of the independent and control variables, data were sourced from Winetitles (https://www.winetitles.com.au), which offers the most extensive database on Australian wine firms. Once collection was complete, all data were merged into a single SPSS file for analysis.

Survey studies have the potential to introduce various biases (Huse et al. 2011); namely, common method and social desirability. To reduce such biases, some procedural techniques were used. First, in order to reduce the extent of common method variance, I undertook the following suggestions from Spector and Brannick (1995) into the survey instrument. These included random ordering the sequence of scale items; reverse-coding certain items; not implying any preferred response; paiding close attention to the wording; and providing succinct instructions for survey completion. A *post-hoc* Harman's single-factor test was conducted (Podsakoff and Organ 1986). The factor analysis test revealed the absence of a single general factor accounting for most of the observed covariance in the variables. Hence, common method bias did not appear to a problem with this dataset.

Second, following Spector and Brannick (1995), social desirability bias was addressed by using a self-administered survey, ensuring complete anonymity for all respondents, and survey questions addressing dependent and independent variables being placed apart from each other in the survey. According to Nederhof (1985), self-administered surveys may reduce social desirability bias over other data collection methods because they reduce the salience of social cues by isolating the subject. In fact, studies find that the use of self-administered surveys is generally found to be less influenced by social desirability bias than telephone or face-to-face interviews

(Nederhof 1985; Wiseman 1972). Hence, indications suggest that anonymous self-administration of mail surveys gives rise to less distortion than other methods (Nederhof 1985).

Dependent variable

After an extensive literature review, a conclusion was made that there is no standard or benchmark measure of adaptive practices in the wine industry. That being the case, and following the process of formative construct development (Bollen and Lennox 1991), a literature review was undertaken to identify items that would serve as an index of practices related to adaptive response. Previous studies in the wine industry, such as those by Galbreath (2011, 2014), were reviewed. The list of adaptive practices was subjected to review and consultation with an academic with expertise in the fields of oenology and viticulture and who had several years' experience studying climate change in the wine industry. After this consultation, and cross-referencing the literature, the index was narrowed down to eight practices that best typified adaptive response—each given equal weight. The dependent variable was, therefore, a formative construct, consisting of seven equally weighted practices.

To measure the dependent variable, respondents were asked to assess the extent to which they agreed (on a seven-point Likert scale ranged from 1 = strongly disagree to 7 = strongly agree) that their firm: "is developing wine products based on hotter climate varieties," "closely monitors water use," "relies on canopy management techniques that shade and protect grape vines from over exposure to heat," "is establishing vineyards in cooler locations," "applies water-saving techniques in the vineyard," "utilizes vineyard orientations that help to reduce short-term exposure to unusually intense sunlight,", "has developed water draining techniques in the vineyard," and "has processes in place to respond to extreme weather events." To assess this formative indicator, regression analysis revealed that significant collinearity was not present between the practices in the index (highest VIF of 1.78). This provides *prima facia* evidence that a formative indicator is suitable (Diamantopoulus and Winklhofer 2001). Hence, the mean was taken across the seven practices to create a variable for analysis.

Independent variables

Temperature (in Celsius) and rainfall (in millimetres) data were collected for firms based on location. More specifically, wine firms within Australia are classified by geographic indication (GI) zones (https://www.wineaustralia.com). A GI zone is a geographic location of origin. To capture the climatic effects, firms in South Australia were first classified according to their GI zone, totaling seven in all. However, to achieve the most appropriate spatial relevance, they were further classified by GI sub-zone. A GI sub-zone is a denser spatial location, meaning weather-related changes are more spatially relevant. Given that not all firms in all GI sub-zones returned surveys, in all, there were 11 GI sub-zones included in the study.

To determine changes in temperature and rainfall, the minimum baseline timeframe for examining climatic changes has been recommended as 30 years by the World Meteorological Organisation.[1] Hence, temperature and rainfall data were collected from the Australian Bureau of Meteorology website, based on the weather station in each of the 11 GI sub-zones which contained the most complete information for the years studied. To calculate the change (Δ) in temperature and rainfall, the annual mean for 1982 was subtracted from the annual mean for 2012 (30 years). Each firm in each relevant GI sub-zone was assigned its respective change in both temperature and rainfall.

[1] See http://www.wmo.int/pages/prog/wcp/ccl/faq/faq_doc_en.html.

Moderating variable

To measure absorptive capacity, the survey included items designed to capture the construct, which were adapted from Delmas et al. (2011). Respondents were asked to assess 10 items on a seven-point Likert scale, ranging from 1 = strongly disagree to 7 = strongly agree. Examples of items included: "we have difficulty in grasping opportunities for our business from new external knowledge (reverse coded)," "our business quickly recognizes the usefulness of new external knowledge to existing knowledge," "our business regularly reconsiders technologies and adapts them accordant to new knowledge," "we constantly consider how to better exploit knowledge," and "our business experiences difficulties in implementing changes required to meet external change (reverse coded)." After refinement, confirmatory factor analysis (CFA) indicated that the final model was a good fit (CFI = 0.95; RMSEA = 0. 0.06), and the loadings of the items were significant (p < .001). The Cronbach alpha is 0.79, demonstrating sufficient reliability for the construct.

Control variables

A few key factors are controlled for. First, larger firms may have more resources in invest in adaptive practices (Galbreath 2011). To control for firm size, the number cases that a firm produces is included. Firm size is thus measured by: 1 = up to 2,499 cases produced annually; 2 = 2,500 to 19,999 cases produced annually; 3 = 20,000 to 99,999 cases produced annually; 4 = 100,000 to 1,499,000 cases produced annually; and 5 = over 1,500,000 cases produced annually. Second, firms that export could face greater institutional pressure to demonstrate a response to climate change (Berrone et al. 2010; Delmas 2002). Export intensity was measured where: 1 = do not export, 2 = 1 to 25 percent, 3 = 26 to 50 percent, 4 = 51 to 75 percent, and 5 = 76 to 100 percent.

With respect to a third consideration, the scholarly treatment of climate change acknowledges time as a factor (Keith 2009; Slawinski and Bansal 2012; Slawinski et al. 2017; Winn et al. 2011). More specifically, changes in climate are manifested over long periods of time. Hence, to control for time-related influences, firm age is measured. The Winetitles database provides information on the founding year of the firm. Hence, firms age is calculated as the difference between 2012 (the year the survey was conducted) and the founding year of the firm. Due to the skewed nature of the data, the log of firm age was taken. Lastly, changes in climate may be location specific (Haigh and Griffiths 2009; IPCC 2007). Therefore, 11 GI sub-zone dummy variables were created to account for any location effects.

[insert Table 1 here]

Results

Key demographics are presented in Table 1, while means, standard deviations, and correlations are presented in Table 2. Although there are significant correlations between some of the control and predictor variables, the correlations are well below 0.80. Correlations below 0.80 minimizes concerns over multicollinearity (O'Brien 2007). Further, the highest variation inflation factor of 4.075 and the lowest tolerance value of .245 are considered to be within acceptable standards (O'Brien 2007), providing further evidence that multicollinearity is unlikely to be problematic in the regression analysis.

[insert Table 1 here]

Table 3 presents the results of the moderated hierarchical regression analysis. Moderated hierarchical regression analysis is used to determine R^2 changes, which aids in interpreting the impact of model fit and significance for both the independent and moderating variables (Baron and Kenny 1986). Prior to analysis, interaction variables were centered. In Step 1, the control variables were entered; in Step 2, the independent variables were added; and in Step 3, the interaction variables were added. Significant interaction indicates a moderating effect (Baron and Kenny 1986). Hypothesis 1 posits that climate change (change in temperature) is associated with adaptive practices. As shown in Model 2, there is support for this hypothesis, as change in temperature is significantly associated with the dependent variable ($\beta = 0.22$; $p < 0.001$).

[insert Table 3 here]

Hypothesis 2 posits that climate change (change in rainfall) is associated with adaptive practices. Model 2 demonstrates that change in rainfall is significantly associated with adaptive practices, offering support for the hypothesis. Hypotheses 3 and 4 put forth that the relationships between climate change (changes in temperature and rainfall) and adaptive practices is moderated by absorptive capacity. Model 3 suggests that there is support for these hypotheses, as the interaction terms are significant for the moderating effect of absorptive capacity on both temperature change ($\beta = 0.91$; $p < 0.001$) and rainfall change ($\beta = 0.88$; $p < 0.001$).

Discussion

The way that firms respond to climate change, and why, is a complex issue. While there is the belief that firms have a moral obligation to respond, one based on a stewardship ethic of looking after the natural environment and care for non-human nature's bounty and limits, a logical questions arises as to the impact and role of *physical* changes in the climate. This study set out to explore such a question and finds that changes in both temperature and rainfall do impact on adaptive practices. Further, absorptive capacity, or a firm's ability to learn from and leverage external knowledge, moderates the relationship between changes in temperature and rainfall and adaptive practices. The results provide a few key contributions.

First, the paper tests relatively new theory with respect to climate change. Starik (1995) and Driscoll and Starik (2004) are early pioneers in developing a theory that the natural environment should have stakeholder standing, and therefore firms should be accountable for responding appropriately. Haigh and Griffiths (2009), relying further on the work of Mitchell et al. (1997), extend the theory by positing that climate change is a *primary* stakeholder because climate change has power, legitimacy, and urgency. Haigh and Griffiths (2009), in effect, have developed natural stakeholder-based theory (NSBT). NSBT incorporates expected impacts of physical changes in the climate. Physical changes in the climate may or may not be readily noticeable, depending on their magnitude (e.g., Galbreath, 2014). In the case of this study, the average change (difference) in temperature from 1982 to 2012 (30 years) was .46° C, while the average change in rainfall was 95.49mm. Following Haigh and Griffiths (2009), such changes act to legitimate the science behind climate change, and therefore climate change has legitimacy. Such changes can also have power in that they can physically impact or effect business activity (Bergmann et al. 2016; Bremer and Linnenluecke 2016; Davenport 2014; Fleming et al. 2015; Tashman and Rivera 2016). Further, such changes can induce a sense of urgency in that they can, and already are, putting firms at risk (Davenport 2014; Galbreath 2011; Haigh and Griffiths 2009; Winn et al. 2011). The findings demonstrated here suggest that changes in both temperature and rainfall are directly associated with adaptive practices, and therefore contributes to the literature by conducting one of the few tests of NSBT.

Here, the study is not only one of the few to empirically test NSBT, but also extends previous findings. For example, in his study of wine firms in Western Australia, Galbreath (2014) suggests that there is little evidence that NSBT can be confirmed. More specifically, he examined 12 firms to understand climate change and how these firms are responding. By conducting interviews and presenting qualitative findings, the study finds that some firms do have a sense of moral obligation to treat the natural environment well and take a stewardship approach to natural resources. However, overall, the study concludes that there may be doubt that climate change has power, legitimacy, or urgency. Yet, he did not measure actual changes in temperature or rainfall. Further, he did not empirically examine if firms are, or are not, detecting, or adequately leveraging, knowledge about any climatic changes, which leads to a second contribution of the present study.

Second, required change to the external environment can be weakened if firms have low levels of effective learning processes and systems that enable them to adapt (Pinske et al. 2010). Further, effective learning processes and systems are applicable not only to technological change, but also to changes in managerial techniques and knowledge about social or political contexts (Lane et al. 2006). Hence, dynamically, firms learn and adapt through the creation of new knowledge, based on complementarity with existing knowledge, to affect change and innovation (Cohen and Levinthal 1990). As firms learn from their local conditions, and combine new knowledge with existing stocks, they are expected to be better positioned to respond to needed change and adapt. Yet, not all firms have the same capacity or capability to do this. Here, a firm's absorptive capacity refers to a capability that firms have to uptake and integrate new external knowledge and, as such, represents one of the fundamental learning processes of an organization (Lane et al. 2006). As climatic conditions shift, particularly for a weather-dependent industry such as wine production, firms would be expected to uptake this information. However, what they do with it and the extent to which they act could be influenced by their levels of absorptive capacity. This study extends the literature by building and testing a theory that firms' adaptation to changes in temperature and rainfall is strengthened when they have stronger levels of absorptive capacity. Support for the proposition is found. Therefore, a second contribution to theory is established.

Lastly, there are managerial contributions. Galbreath (2014) finds that some firms are skeptical that climatic changes are occurring or, alternatively, believe that changes will be beneficial—to a point. Yet, the present study finds that, at least over the last 30 years in a specific part of Australia, that changes in both temperature and rainfall are occurring. While this study does not explore the *cause* of these changes, firms can be left vulnerable or at risk unless they adapt (IPCC 2007). Hence, firms should explore options with respect to how they adapt to changes in temperature and rainfall, ensuring that operations are capable of coping. Firms such as Coca-Cola Company and Nike are already demonstrating such approaches (Davenport 2014). Further, managers should ensure that they have developed capabilities within their firms to absorb stimuli (e.g., climate-related information) from the external environment, combine with existing knowledge, and apply it to adaptive and technical change.

Limitation, future research, and conclusion

This study is not without limitations. First, a single industry (wine) in a single context (Australia) comprises the sample. A sample such as this limits generalizeability. However, management research that examines the impact of climatic changes on firm adaptation is needed (Bergmann et al. 2016; Tashman and Rivera, 2016), and thus expands the study of NSBT. Future research could explore different industries in different parts of the world to further expand our understanding of climatic changes and NSBT. Second, only adaptation practices were examined. While such an approach does advance the “outside in” perspective (Bergmann et al. 2016), what is not clear is to what extent actual, physical changes in the climate, are leading to mitigation practices. Future studies could take into account impacts of changes in climate and mitigative practices, or else determine if there are differences in uptake in mitigative relative to adaptive practices based on these changes in climate. Third, this study examines only one type of internal capability as a moderating influence; namely, absorptive capacity. Further research is needed to determine if other organizational aspects, such as culture, or human agency, such as a leader's moral orientation, either weaken or strengthen the relationship between changes in climate and adaptive practices. Lastly, due to budgetary constraints and data restrictions, only a 30-year, cross-sectional slice of time is employed. Although 30 years is the prescribed recommendation to account for changes in climate, future studies could look at time-series, panel data to enable a greater capacity for capturing the complexity of variable interactions than a cross-section, and where possible, include longer time periods.

In conclusion, climate change is considered a great moral, political, and social issue of the day (Carrell 2012; Fleming et al. 2015; Howard-Grenville et al. 2014). Yet, surprisingly, little management research has actually studied the impact of physical changes in the climate on firm behavior (Bergmann et al. 2016; Tashman and Rivera 2016). This study seeks to respond to such lack of research by relying on NSBT and building a set of arguments that changes in both temperature and rainfall have power, legitimacy, and urgency and, therefore, impact on firms' adaptive practices. The results demonstrate support for the arguments. Further, the study finds that the impact of changes in the climate on the way a firm responds through adaptive practices is positively moderated by their levels of absorptive capacity. For managers, while there may be moral or other internally-driven reasons to consider response to climate change (Galbreath 2014), this study suggests that externally, changes in climate are occurring and directly influence firm behavior. Therefore, paying attention to climate change (cf. Pinske and Gasbarro 2016) and considering an appropriate level of response is warranted.

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Tables

Table 1. Key demographics

Key demographics					
Cases produced		Cases exported		Age of winery	
	(%)		(%)		(Years)
> 1,500,000	1.1	76-100%	8.3	Youngest	1
100,000-1,499,999	8.2	51-75%	10.6	Oldest	176
20,000-99,999	21.2	26-50%	26.1		
2,500-19,999	39.6	1-25%	43.3		
2,499 or less	29.9	Do not export	11.7		
	100		100		

Table 2. Descriptive statistics and correlations

Variable	Mean	*SD*	1	2	3	4	5	6	7
1. Adaptive practices	4.18	1.39	1.00						
2. Firm size	2.11	.96	.18*	1.00					
3. Export intensity	2.61	1.09	.01	.50**	1.00				
4. Firm age (log)	1.26	.40	.15*	.49**	.16*	1.00			
5. Temperature change 2012 -1982 (Celsius)	.46	.18	.14*	.07	.15*	.23**	1.00		
6. Rainfall change 2012 -1982 (mm)	95.49	39.63	.04	.09	.08	-.08	-.34**	1.00	
7. Absorptive capacity	4.98	1.01	.22**	24**	-.00	.28**	-.07	.03	1.00

* $p < 0.05$; ** $p < 0.01$

Table 3. Moderated regression analysis

Variables	Model 1 Control variables	Model 2 Direct effects	Model 3 Interaction effects
	β	β	β
Firm size	0.26***	0.23***	0.18**
Export intensity	-0.08	-0.08	-0.06
Firm age (log)	0.03	0.03	0.01
Location dummies	Yes	Yes	Yes
Temperature change		0.22***	0.18**
Rainfall change		0.30***	0.19**
Absorptive capacity		0.34***	0.16**
Temperature change x absorptive capacity			0.91***
Rainfall change x absorptive capacity			0.88***
R	0.234	0.282	0.384
R^2	0.055	0.079	0.147
F	8.75***	6.45***	9.64***
ΔR^2		0.024**	0.068***

n = 207 firms

** $p < 0.01$

*** $p < 0.001$